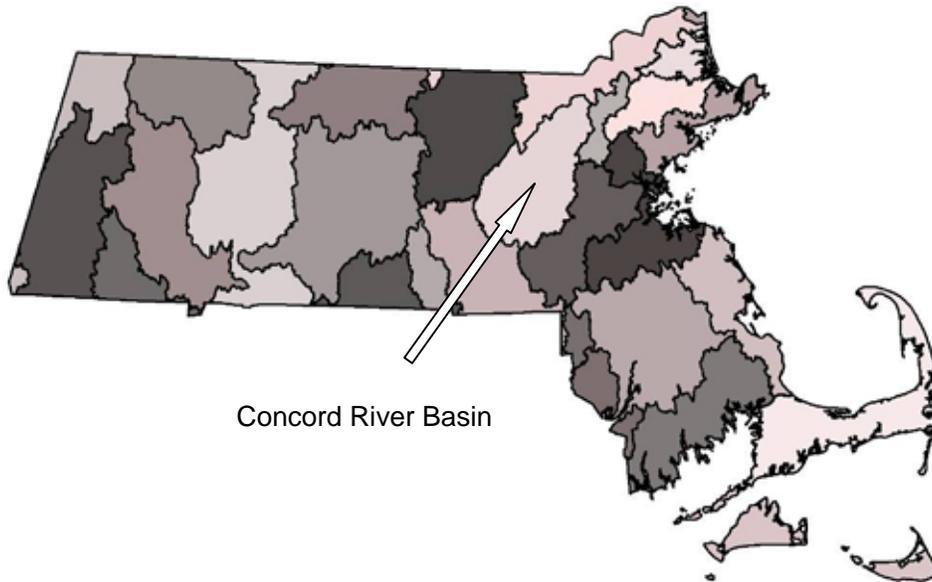


Draft Pathogen TMDL for the Concord River Watershed



Prepared as a cooperative effort by:

Massachusetts DEP
1 Winter Street
Boston, Massachusetts 02108

USEPA New England Region 1
1 Congress Street, Suite 1100
Boston, Massachusetts 02114



ENSR International
2 Technology Park Drive
Westford, MA 01886

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Massachusetts Department of Environmental Protection (MADEP)
Division of Watershed Management
627 Main Street
Worcester, Massachusetts 01608

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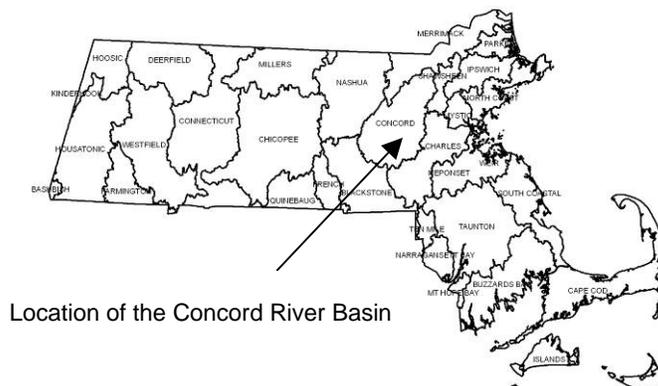
References to trade names, commercial products, manufacturers, or distributors in this report constituted neither endorsement nor recommendations by the Division of Watershed Management for use.

Much of this document was prepared using text and general guidance from the previously approved Neponset River Basin and the Palmer River Basin Bacteria Total Maximum Daily Load documents.

Acknowledgement

This report was developed by ENSR through a partnership with Resource Triangle Institute (RTI) contracting with the United States Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Protection Agency under the National Watershed Protection Program.

Draft Total Maximum Daily Loads for Pathogens within the Concord River Watershed



Key Features:	Pathogen TMDL for the Concord River Watershed
Location:	EPA Region 1
Land Type:	New England Upland
303(d) Listings:	Pathogens Assabet River (MA82B-01; MA82B-02; MA82B-03; MA82B-04; MA82B-05; MA82B-07); Concord River (MA82A-07; MA82A-09); Grist Mill Pond (MA82055); Hager Pond (MA82056); River Meadow Brook (MA82A-10); Hop Brook (MA82A-06)
Data Sources:	<ul style="list-style-type: none">MADEP “SuAsCo Watershed 2001 Water Quality Assessment Report – Final Draft” May 2005ENSR “Sudbury River Water Quality Study 2002 – 2003 Final Report”, November 2004.ENSR “2004 Sudbury River Targeted Sub-Basin Bacteria Sampling” November 2004Organization for the Assabet River “Streamwatch and Water Quality Monitoring Program Final Report – Summer 2002” December 2003.ENSR “SuAsCo Watershed Concord River TMDL Study Assessment Final Report” February 2003.
Data Mechanism:	Massachusetts Surface Water Quality Standards for Fecal Coliform; Massachusetts Department of Public Health Bathing Beaches
Monitoring Plan:	Massachusetts Watershed Five-Year Cycle
Control Measures:	Watershed Management; Storm Water Management (e.g., illicit discharge removals, public education/behavior modification); CSO & SSO Abatement; BMPs; By-laws; Ordinances; Septic System Maintenance/Upgrades

Executive Summary

Purpose and Intended Audience

This document provides a framework to address bacterial and other fecal-related pollution in surface waters of Massachusetts. Fecal contamination of our surface waters is most often a direct result of the improper management of human wastes, excrement from barnyard animals, pet feces and agricultural applications of manure. It can also result from large congregations of birds such as geese and gulls. Illicit discharges of boat waste are of particular concern in coastal areas. Inappropriate disposal of human and animal wastes can degrade aquatic ecosystems and negatively affect public health. Fecal contamination can also result in closures of shellfish beds, beaches, swimming holes and drinking water supplies. The closure of such important public resources can erode quality of life and diminish property values.

Who should read this document?

The following groups and individuals can benefit from the information in this report:

- a) towns and municipalities, especially Phase I and Phase II storm water communities, that are required by law to address storm water and/or combined sewage overflows (CSOs) and other sources of contamination (e.g., broken sewerage pipes and illicit connections) that contribute to a waterbody's failure to meet Massachusetts Water Quality Standards for pathogens;
- b) watershed groups that wish to pursue funding to identify and/or mitigate sources of pathogens in their watersheds;
- c) public health officials and/or municipalities that are responsible for monitoring, enforcing or otherwise mitigating fecal contamination that results in beach closures or results in the failure of other surface waters to meet Massachusetts standards for pathogens;
- d) citizens that wish to become more aware of pollution issues and may be interested in helping build local support for funding remediation measures.

TMDL Overview

The Massachusetts Department of Environmental Protection (MADEP) is responsible for monitoring the waters of the Commonwealth, identifying those waters that are impaired, and developing a plan to bring them back into compliance with the Massachusetts Water Quality Standards (WQS). The list of impaired waters, better known as the "303d list" identifies problem lakes, coastal waters and specific segments of rivers and streams and the reason for impairment.

Once a water body is identified as impaired, the MADEP is required by the Federal Clean Water Act (CWA) to develop a “pollution budget” designed to restore the health of the impaired body of water. The process of developing this budget, generally referred to as a Total Maximum Daily Load (TMDL), includes identifying the source(s) of the pollutant from direct discharges (point sources) and indirect discharges (non-point sources), determining the maximum amount of the pollutant that can be discharged to a specific water body to meet water quality standards, and assigning pollutant load allocations to the sources. A plan to implement the necessary pollutant reductions is essential to the ultimate achievement of meeting the water quality standards.

Pathogen TMDL: This report represents a TMDL for pathogen indicators (e.g. fecal coliform, *E. coli*, and enterococcus bacteria) in the Concord River watershed, also commonly referred to as the SuAsCo for the three main rivers within the basin (the Sudbury, Assabet and Concord Rivers). Certain bacteria, such as coliform, *E. coli*, and enterococcus bacteria, are indicators of contamination from sewage and/or the feces of warm-blooded wildlife (mammals and birds). Such contamination may pose a risk to human health. Therefore, in order to prevent further degradation in water quality and to ensure that waterbodies within the watershed meet state water quality standards, the TMDL establishes indicator bacteria limits and outlines corrective actions to achieve that goal.

Sources of indicator bacteria in the Concord River watershed were found to be many and varied. Most of the bacteria sources are believed to be storm water related. Table ES-1 provides a general compilation of likely bacteria sources in the Concord River watershed including failing septic systems, combined sewer overflows (CSO), sanitary sewer overflows (SSO), sewer pipes connected to storm drains, certain recreational activities, wildlife including birds along with domestic pets and animals and direct overland storm water runoff. Note that bacteria from wildlife would be considered a natural condition unless some form of human inducement, such as feeding, is causing congregation of wild birds or animals. A discussion of pathogen related control measures and best management practices are provided in the companion document: “*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*”.

This TMDL applies to the 12 pathogen impaired segments of the Concord River watershed that are currently listed on the CWA § 303(d) list of impaired waters. MADEP recommends however, that the information contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing “pollution prevention TMDLs” consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This Concord River watershed TMDL may, in appropriate circumstances, also apply to segments that are listed for pathogen impairment in subsequent Massachusetts CWA § 303(d) Integrated List of Waters. For such segments, this TMDL may apply if, after listing the waters for pathogen impairment and taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

Since accurate estimates of existing sources are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For the illicit sources, the goal is complete elimination (100% reduction). However, overall wet weather indicator bacteria load reductions can be estimated using typical storm water bacteria concentrations. These data indicate that in general two to three orders of magnitude (i.e., greater than 90%) reductions in storm water fecal coliform loading will be necessary, especially in developed areas. This goal is expected to be accomplished through implementation of best management practices, such as those associated with the Phase II control program for storm water.

TMDL goals for each type of bacteria source are provided in Table ES-1. Municipalities are the primary responsible parties for eliminating many of these sources. TMDL implementation to achieve these goals should be an iterative process with selection and implementation of mitigation measures followed by monitoring to determine the extent of water quality improvement realized. Recommended TMDL implementation measures include identification and elimination of prohibited sources such as leaky or improperly connected sanitary sewer flows and best management practices to mitigate storm water runoff volume. Certain towns in the watershed are classified as Urban Areas by the United States Census Bureau and are subject to the Stormwater Phase II Final Rule that requires the development and implementation of an illicit discharge detection and elimination plan. Combined sewer overflows will be addressed through the on-going long-term control plans.

In most cases, authority to regulate non-point source pollution and thus successful implementation of this TMDL is limited to local government entities and will require cooperative support from local volunteers, watershed associations, and local officials in municipal government. Those activities can take the form of expanded education, obtaining and/or providing funding, and possibly local enforcement. In some cases, such as subsurface disposal of wastewater from homes, the Commonwealth provides the framework, but the administration occurs on the local level. Among federal and state funds to help implement this TMDL are, on a competitive basis, the Non-Point Source Control (CWA Section 319) Grants, Water Quality (CWA Section 604(b)) Grants, and the State Revolving (Loan) Fund Program (SRF). Most financial aid requires some local match as well. The programs mentioned are administered through the MADEP. Additional funding and resources available to assist local officials and community groups can be referenced within the Massachusetts Non-point Source Management Plan-Volume I Strategic Summary (2000) "Section VII Funding / Community Resources". This document is available on the MADEP's website at: www.state.ma.us/dep/brp/wm/wmpubs.htm, or by contacting the MADEP's Nonpoint Source Program at (508) 792-7470 to request a copy.

Table ES-1. Sources and Expectations for Limiting Bacterial Contamination in the Concord River Watershed

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL)¹	Load Allocation Indicator Bacteria (CFU/100 mL)¹
A & B	Illicit discharges to storm drains	0	N/A
A & B	Leaking sanitary sewer lines	0	N/A
A & B	Failing septic systems	N/A	0
A	NPDES – WWTP	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms ²	N/A
A	Storm water runoff Phase I and II	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms ³	N/A
A	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed an arithmetic mean of 20 organisms in any set of representative samples, nor shall 10% of the samples exceed 100 organisms ³
B	CSOs	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms ⁴	N/A
B	NPDES – WWTP	Shall not exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms ²	N/A
B	Storm water runoff Phase I and II	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms ³	N/A
B	Direct storm water runoff not regulated by NPDES and livestock, wildlife & pets	N/A	Not to exceed a geometric mean of 200 organisms in any set of representative samples, nor shall 10% of the samples exceed 400 organisms ³

Surface Water Classification	Pathogen Source	Waste Load Allocation Indicator Bacteria (CFU/100 mL) ¹	Load Allocation Indicator Bacteria (CFU/100 mL) ¹
Fresh Water Beaches ⁵	All Sources	<p>Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies</p> <p>OR</p> <p><i>E. coli</i> not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies</p>	<p>Enterococci not to exceed a geometric mean of 33 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 61 colonies</p> <p>OR</p> <p><i>E. coli</i> not to exceed a geometric mean of 126 colonies of the five most recent samples within the same bathing season, nor shall any single sample exceed 235 colonies</p>

N/A means not applicable

¹ Waste Load Allocation (WLA) and Load Allocation (LA) refer to fecal coliform densities unless specified in table.

² Or shall be consistent with the Waste Water Treatment Plant (WWTP) National Pollutant Discharge Elimination System (NPDES) permit.

³The expectation for WLAs and LAs for storm water discharges is that they will be achieved through the implementation of BMPs and other controls.

⁴ Or shall be consistent with an approved Long Term Control Plan (LTCP) for Combined Sewer Overflow (CSO) abatement. If the level of control specified in the LTCP is less than what is necessary to attain Class B water quality standards, then the above criteria apply unless MADEP has proposed and EPA has approved water quality standards revisions for the receiving water.

⁵ Massachusetts Department of Public Health regulations (105 CMR Section 445)

Note: this table represents waste load and load reductions based on water quality standards current as of the publication date of these TMDLs, any future changes made to the Massachusetts water quality standards will become the governing water quality standards for these TMDLs.

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**Appendix A Lower Charles River Illicit Discharge Detection & Elimination (IDDE)
Protocol Guidance for Consideration - November 2004**

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1.0 Introduction

Section 303(d) of the Federal Clean Water Act (CWA) and Environmental Protection Agencies (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to place waterbodies that do not meet established water quality standards on a list of impaired waterbodies (commonly referred to as the "303d List") and to develop Total Maximum Daily Loads (TMDLs) for listed waters and the pollutant(s) contributing to the impairment. In Massachusetts, impaired waterbodies are included in Category 5 of the "*Massachusetts Year 2002 Integrated List of Water: Part 2- Final Listing of Individual Categories of Waters*" (2002 List; MADEP 2003). Figure 1-1 provides a map of the Concord River watershed (also referred to as the SuAsCo Watershed) with pathogen impaired segments indicated. Please note that not all segments have been assessed by the Massachusetts Department of Environmental Protection (MADEP) for pathogen impairment. As shown in Figure 1-1, much of the Concord River waterbodies are listed as a Category 5 "impaired or threatened for one or more uses and requiring a TMDL" due to excessive indicator bacteria concentrations.

TMDLs are to be developed for water bodies that are not meeting designated uses under technology-based controls. TMDLs determine the amount of a pollutant that a waterbody can safely assimilate without violating water quality standards. The TMDL process establishes the maximum allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollutant sources and instream conditions. The TMDL process is designed to assist states and watershed stakeholders in the implementation of water quality-based controls specifically targeted to identified sources of pollution in order to restore and maintain the quality of their water resources (USEPA 1999). TMDLs allow watershed stewards to establish measurable water quality goals based on the difference between site-specific instream conditions and state water quality standards.

A major goal of this TMDL is to achieve meaningful environmental results with regard to the designated uses of the Concord River watershed waterbodies. These include water supply, fishing, boating, and swimming. This TMDL establishes the necessary pollutant load to achieve designated uses and water quality standard and the companion document entitled; "*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*" provides guidance for the implementation of this TMDL.

Historically, water and sediment quality studies have focused on the control of point sources of pollutants (i.e., discharges from pipes and other structural conveyances) that discharge directly into well-defined hydrologic resources, such as lakes, ponds, or river segments. While this localized approach may be appropriate under certain situations, it typically fails to characterize the more subtle and chronic sources of pollutants that are widely scattered throughout a broad geographic region such as a watershed (e.g., roadway runoff, failing septic systems in high groundwater, areas of concentrated wildfowl use, fertilizers, pesticides, pet waste, and certain agricultural sources). These so called nonpoint sources of pollution often contribute significantly to the decline of water quality through their cumulative impacts. A watershed-level approach that uses the surface drainage

Figure 1-1. Concord River Watershed and Pathogen Impaired Segments.

area as the basic study unit enables managers to gain a more complete understanding of the potential pollutant sources impacting a waterbody and increases the precision of identifying local problem areas or “hot spots” which may detrimentally affect water and sediment quality. It is within this watershed-level framework that the MADEP commissioned the development of watershed based TMDLs.

1.1. Pathogens and Indicator Bacteria

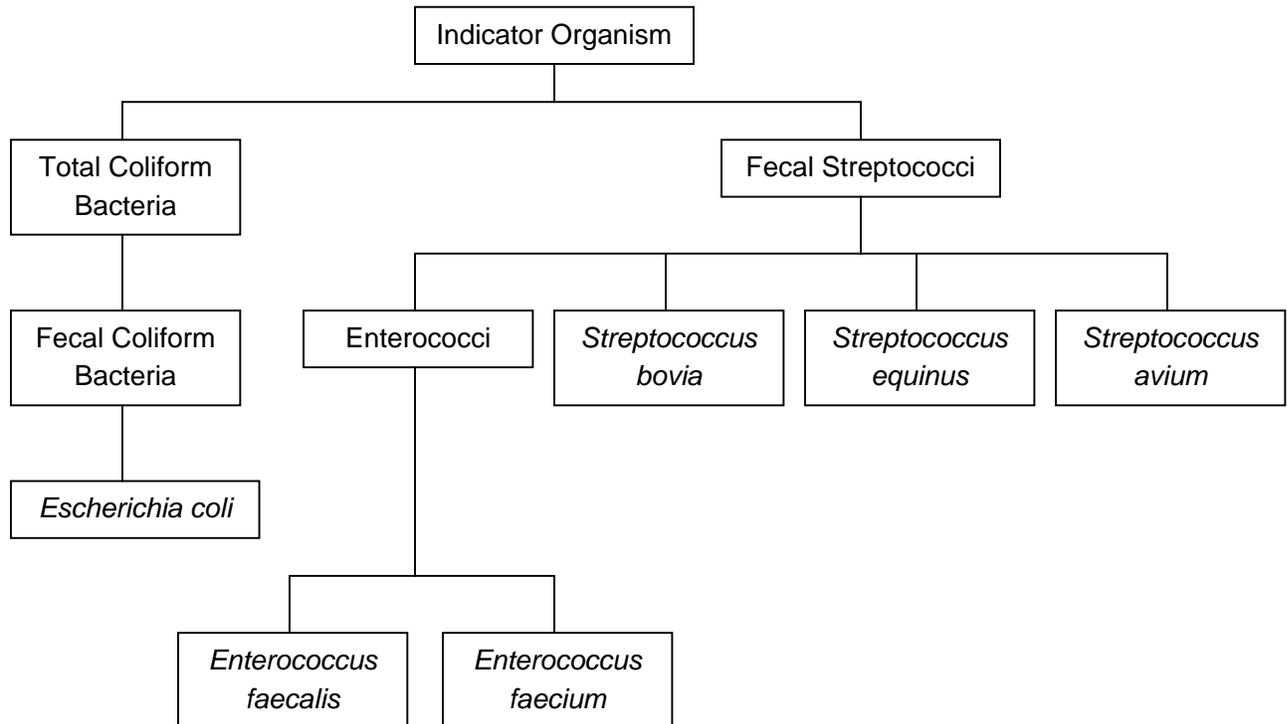
The Concord River pathogen TMDL is designed to support reduction of waterborne disease-causing organisms, known as pathogens, to reduce public health risk. Waterborne pathogens enter surface waters from a variety of sources including sewage and the feces of warm-blooded wildlife. These pathogens can pose a risk to human health due to gastrointestinal illness through exposure via ingestion and contact with recreational waters, ingestion of drinking water, and consumption of filter-feeding shellfish.

Waterborne pathogens include a broad range of bacteria and viruses that are difficult to identify and isolate. Thus, specific nonpathogenic bacteria have been identified that are typically associated with harmful pathogens in fecal contamination. These associated nonpathogenic bacteria are used as indicator bacteria as they are easier to identify and measure in the environment. High densities of indicator bacteria increase the likelihood of the presence of pathogenic organisms.

Selection of indicator bacteria is difficult as new technologies challenge current methods of detection and the strength of correlation of indicator bacteria and human illness. Currently, coliform and fecal streptococci bacteria are commonly used as indicators of potential pathogens (i.e., indicator bacteria). Coliform bacteria include total coliforms, fecal coliform and *Escherichia coli* (*E. coli*). Fecal coliform (a subset of total coliform) and *E. coli* (a subset of fecal coliform) bacteria are present in the intestinal tracts of warm blooded animals. Presence of coliform bacteria in water indicates fecal contamination and the possible presence of pathogens. Fecal streptococci bacteria are also used as indicator bacteria, specifically enterococci a subgroup of fecal streptococci. These bacteria also live in the intestinal tract of animals, but their presence is a better predictor of human gastrointestinal illness than fecal coliform since the die-off rate of enterococci is much lower (i.e., enterococci bacteria remain in the environment longer) (USEPA 2001). The relationship of indicator organisms is provided in Figure 1-2. The EPA, in the “*Ambient Water Quality Criteria for Bacteria – 1986*” document, recommends the use of *E. coli* or enterococci as potential pathogen indicators in fresh water and enterococci in marine waters (USEPA 1986).

Massachusetts uses fecal coliform and enterococci as indicator organisms of potential harmful pathogens. The WQS that apply to fresh water are currently based on fecal coliform concentration but will be replaced with *E. coli*. Fecal coliform are also used by the Massachusetts Division of Marine Fisheries (DMF) in their classification of shellfish growing areas. Fecal coliform as the indicator organism for shellfish growing area status is not expected to change at this time. Enterococci are used as the indicator organism for marine beaches, as required by the Beaches Environmental Assessment and Coastal Act of 2000 (BEACH Act), an amendment to the CWA.

Figure 1-2. Relationships among Indicator Organisms (USEPA 2001).



The Concord River watershed pathogen TMDLs have been developed using fecal coliform as an indicator bacterium for fresh waters. Any changes in the Massachusetts pathogen water quality standard will apply to this TMDL at the time of the standard change. Massachusetts believes that the magnitude of indicator bacteria loading reductions outlined in this TMDL will be both necessary and sufficient to attain present WQS and any future modifications to the WQS for pathogens.

1.2. Comprehensive Watershed-based Approach to TMDL Development

Consistent with Section 303(d) of the CWA, the MADEP has chosen to complete pathogen TMDLs for all waterbodies in the Concord River watershed at this time, regardless of current impairment status (i.e., for all waterbody categories in the *2002 List*). MADEP believes a comprehensive management approach carried out by all watershed communities is needed to address the ubiquitous nature of pathogen sources present in the Concord River watershed. Watershed-wide implementation is needed to meet WQS and restore designated uses in impaired segments while providing protection of desirable water quality in waters that are not currently impaired or not assessed.

As discussed below, this TMDL applies to the 12 pathogen impaired segments of the Concord River watershed that are currently listed on the CWA § 303(d) list of impaired waters and determined to be pathogen impaired in the “SuAsCo 2001 *Water Quality Assessment Report – Final Draft*” (WQA; MADEP 2005) (see Figure 1-1, Table 4-3). MADEP recommends however, that the information

contained in this TMDL guide management activities for all other waters throughout the watershed to help maintain and protect existing water quality. For these non-impaired waters, Massachusetts is proposing “pollution prevention TMDLs” consistent with CWA § 303(d)(3).

The analyses conducted for the pathogen impaired segments in this TMDL would apply to the non-impaired segments, since the sources and their characteristics are equivalent. The waste load and/or load allocation for each source and designated use would be the same as specified herein. Therefore, the pollution prevention TMDLs would have identical waste load and load allocations based on the sources present and the designated use of the water body segment (see Table ES-1 and Table 6-1).

This Concord River watershed TMDL may, in appropriate circumstances, also apply to segments that are listed for pathogen impairment in subsequent Massachusetts CWA § 303(d) Integrated List of Waters. For such segments, this TMDL may apply if, after listing the waters for pathogen impairment and taking into account all relevant comments submitted on the CWA § 303(d) list, the Commonwealth determines with EPA approval of the CWA § 303(d) list that this TMDL should apply to future pathogen impaired segments.

There are 97 waterbody segments assessed by the MADEP in the Concord River watershed (MassGIS 2005). These segments consist of 36 river segments, ten of which are pathogen impaired and appear as such on the official impaired waters list (303(d) List) (Figure 1-1). Two of the 61 lake segments are pathogen impaired. Pathogen impairment has been documented by the MADEP in previous reports, including the MADEP WQA, resulting in the impairment determination. In this TMDL document, an overview of pathogen impairment is provided to illustrate the nature and extent of the pathogen impairment problem. Additional data, not collected by the MADEP or used to determine impairment status, may also be provided in this TMDL to illustrate the pathogen problem. Since pathogen impairment has been previously established only a summary is provided herein.

The watershed based approach applied to complete the Concord River watershed pathogen TMDL is straightforward. The approach is focused on identification of sources, source reduction, and implementation of appropriate management plans. Once identified, sources are required to meet applicable WQS for indicator bacteria or be eliminated. This approach does not include water quality analysis or other approaches designed to link ambient concentrations with source loadings. For pathogens and indicator bacteria, water quality analyses are generally resource intensive and provide results with large degrees of uncertainty. Rather, this approach focuses on sources and required load reductions, proceeding efficiently toward water quality restoration activities.

The implementation strategy for reducing indicator bacteria is an iterative process where data are gathered on an ongoing basis, sources are identified and eliminated if possible, and control measures including Best Management Practices (BMPs) are implemented, assessed and modified as needed. Measures to abate probable sources of waterborne pathogens include everything from public education, to improved storm water management, to reducing the influence from inadequate and/or failing sanitary sewer infrastructure.

1.3. TMDL Report Format

This document contains the following sections:

- Watershed Description (Section 2) – provides watershed specific information
- Water Quality Standards (Section 3) – provides a summary of current Massachusetts WQS as they relate to indicator bacteria
- Problem Assessment (Section 4) – provides an overview of indicator bacteria measurements collected in the Concord River watershed
- Identification of Sources (Section 5) – identifies and discusses potential sources of waterborne pathogens within the Concord River watershed
- TMDL Development (Section 6) – specifies required TMDL development components including:
 - Definitions and Equation
 - Loading Capacity
 - Load and Waste Load Allocations
 - Margin of Safety
 - Seasonal Variability
- Implementation Plan (Section 7) – describes specific implementation activities designed to remove pathogen impairment. This section and the companion “*Mitigation Measures to Address Pathogen Pollution in Surface Water: A TMDL Implementation Guidance Manual for Massachusetts*” document should be used together to support implementing management actions
- Monitoring Plan (Section 8) – describes recommended monitoring activities
- Reasonable Assurances (Section 9) – describes reasonable assurances the TMDL will be implemented
- Public Participation (Section 10) – describes the public participation process, and
- References (Section 11)

2.0 Watershed Description

The Concord River covers about 398 square miles and includes three major sub-basins; the Assabet River Basin, the Sudbury River Basin, and the Concord River Basin (USGS 2004). Respectively these rivers have an approximate length of 31.8 miles, 29.1 miles, and 15.4 miles (MADEP 2000a). The Concord River Basin includes all or part of 36 cities and towns within northeastern Massachusetts. The Concord River begins at the junction of the Assabet and Sudbury Rivers in Concord, Massachusetts and flows northward into the Merrimack River, while the Assabet flows northeast and the Sudbury flows north. The Assabet River, 31.8 miles in length and 178 square miles in drainage area, flows northeasterly from its headwaters in the Town of Westborough to its mouth at the confluence with the Sudbury River in the Town of Concord. Along the way it passes through 10 towns and receives contributions from tributaries and subwatersheds in eight other towns (MADEP 2004). The mainstem of the Sudbury River is approximately 32 miles long, and drains a watershed area of 162 square miles, 29 of which drain into Massachusetts District Commission (MDC) reservoirs (ENSR 2004a). The headwaters of the Sudbury River are in Cedar Swamp in Westborough, at an elevation of 265 feet and the downstream extent is at the confluence with the Assabet River at an elevation of 112 feet (ENSR 2004a).

Land use within the watershed is primarily forested with residential areas (Table 2-1). Most of the forested areas lie in the west and northern portion of the watershed whereas dense residential areas are located in the eastern and the most northern portion (Figure 2-1). A discussion of land use characteristics and associated bacteria levels are provided in Section 4.0 of this document.

The upper reaches of the Concord River are slow moving resulting in long residence times for nutrient constituents that result in eutrophic conditions, while the lower reaches have swifter moving waters that aerate the surface waters (ENSR 2003). The Sudbury River upstream flow is diverted as needed for use of Boston metropolitan district. While the reservoirs on the Sudbury River are no longer managed to retain water through the summer, they are managed to enhance habitat in the downstream reaches. The Assabet River receives the discharge from four major municipal wastewater treatment facilities along the course of the river. The river alternates between medium slope free flowing and low-slow impounded reaches (MADEP 2004).

The Concord River and tributaries are commonly used for primary and secondary contact recreation (swimming and boating), fishing, wildlife viewing, habitat for aquatic life, and water supply.

Table 2-1. Concord River Watershed Land Use

Land Use Category	% of Total Watershed Area
Pasture	1.2
Urban Open	1.6
Open Land	2.1
Cropland	3.9
Woody Perennial	0.2
Forest	43.5
Wetland	5.9
Water Based Recreation	<0.1
Water	1.0
General Undeveloped Land	59.5
Spectator Recreation	<0.1
Participation Recreation	1.4
> 1/2 acre lots Residential	14.8
1/4 - 1/2 acre lots Residential	13.2
< 1/4 acre lots Residential	2.0
Multi-family Residential	0.9
Mining	0.3
Commercial	2.5
Industrial	1.9
Transportation	0.2
Waste Disposal	3.4
General Developed Land	40.5

Figure 2-1. Concord River Watershed Land Use as of 1999.

3.0 Water Quality Standards

The Surface Water Quality Standards (WQS) for the Commonwealth of Massachusetts establish chemical, physical, and biological standards for the restoration and maintenance of the most sensitive uses (MADEP 2000a). The WQS limit the discharge of pollutants to surface waters for the protection of existing uses and attainment of designated uses in downstream and adjacent segments.

Fecal coliform, enterococci, and *E. coli* bacteria are found in the intestinal tract of warm-blooded animals, soil, water, and certain food and wood processing wastes. “Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems” (USEPA 2004a). These bacteria are often used as indicator bacteria since it is expensive and sometimes difficult to test for the presence of individual pathogenic organisms.

Massachusetts is planning to revise its freshwater WQS by replacing fecal coliform with *E. coli* and enterococci as the regulated indicator bacteria, as recommended by the EPA in the “*Ambient Water Quality Criteria for Bacteria – 1986*” document (USEPA 1986). The state has already done so for public beaches through regulations of the Massachusetts Department of Public Health as discussed below. Currently, Massachusetts uses fecal coliform as the indicator organism for all waters except for marine bathing beaches, where the Federal BEACH Act requires the use of enterococci. Massachusetts anticipates adopting *E. coli* and enterococci for all fresh waters and enterococci for all marine waters, including non bathing marine beaches. Fecal coliform will remain the indicator organism for shellfishing areas, however. The Concord River watershed pathogen TMDL has been developed using fecal coliform as the pathogen indicator for fresh waters, but the goal of removing pathogen impairment of this TMDL will remain applicable when Massachusetts adopts new indicator bacteria criteria into its WQS. Massachusetts believes that the magnitude of indicator bacteria loading reductions outlined in this TMDL will be both necessary and sufficient to attain present WQS and any future modifications to the WQS for pathogens.

Pathogens can significantly impact humans through ingestion of, and contact with recreational waters, ingestion of drinking water, and consumption of filter-feeding shellfish. In addition to contact recreation, excessive pathogen numbers impact potable water supplies. The amount of treatment (i.e., disinfection) required to produce potable water increases with increased pathogen contamination. Such treatment may cause the generation of disinfection by-products that are also harmful to humans. Further detail on pathogen impacts can be accessed at the following EPA websites:

- Water Quality Criteria: Microbial (Pathogen)
<http://www.epa.gov/ost/humanhealth/microbial/microbial.html>
- Human Health Advisories:
 - Fish and Wildlife Consumption Advisories
<http://www.epa.gov/ebtpages/humaadvisofishandwildlifeconsumption.html>

- Swimming Advisories
<http://www.epa.gov/ebtpages/humaadvisoswimmingadvisories.html>

The Concord River watershed contains waterbodies classified as Class A and Class B. The corresponding WQS for each class are as follows:

Class A waterbodies - fecal coliform bacteria shall not exceed an arithmetic mean of 20 organisms per 100 mL in any representative set of samples, nor shall 10% of the samples exceed 100 organisms per 100 mL.

Class B waterbodies - the geometric mean of a representative set of fecal coliform samples shall not exceed 200 organisms per 100 mL and no more than 10% of the samples shall exceed 400 organisms per 100 mL. The MADEP may apply these standards on a seasonal basis.

In addition to the WQS, the Commonwealth of Massachusetts Department of Public Health (MADPH) has established minimum standards for bathing beaches (105 CMR 445.000) under the State Sanitary Code, Chapter VII (www.mass.gov/dph/dcs/bb4_01.pdf). These standards will soon be adopted by the MADEP as state surface WQS for fresh water and these standards will subsequently apply to this TMDL. The MADPH bathing beach standards are generally the same as those which were recommended in the “*Ambient Water Quality Criteria for Bacteria – 1986*” document published by the EPA (USEPA 1986). In the above referenced document, the EPA recommended the use of enterococci as the indicator bacterium for marine recreational waters and enterococci or *E. coli* for fresh waters. As such, the following MADPH standards have been established for bathing beaches in Massachusetts:

Marine Waters - (1) No single enterococci sample shall exceed 104 colonies per 100 mL and the geometric mean of the most recent five enterococci levels within the same bathing season shall not exceed 35 colonies per 100 mL.

Freshwaters - (1) No single *E. coli* sample shall exceed 235 colonies per 100 mL and the geometric mean of the most recent five *E. coli* samples within the same bathing season shall not exceed 126 colonies per 100 mL; or (2) No single enterococci sample shall exceed 61 colonies per 100 mL and the geometric mean of the most recent five enterococci samples within the same bathing season shall not exceed 33 colonies per 100 mL.

The Federal BEACH Act of 2000 established a Federal standard for marine beaches. These standards are essentially the same as the MADPH marine beach standard (i.e., single sample not to exceed 104 cfu/100mL and geometric mean of a statistically sufficient number of samples not to exceed 35 cfu/100mL). The Federal BEACH Act and MADPH standards can be accessed on the worldwide web at <http://www.epa.gov/waterscience/beaches/act.html> and www.mass.gov/dph/dcs/bb4_01.pdf, respectively.

There are no marine bathing beaches in the Concord River watershed. However, there are numerous freshwater beaches located within the watershed. A list of fresh (and marine) beaches by community with bacteria data can be found in the annual reports on the testing of public and semi-public beaches provided by the MADPH. These reports are available for download from the MADPH website located at <http://www.mass.gov/dph/beha/tox/reports/beach/beaches.htm>.